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Farming in Tsetse Controlled Areas



FITCA

Environmental Monitoring and Management Component

E M M C

Project Number : 7.ACP.RP.R. 578

Atlas of FITCA-EMMC track mapping of Angurai

Joseph Matere and Evanson Njuguna

May 2004



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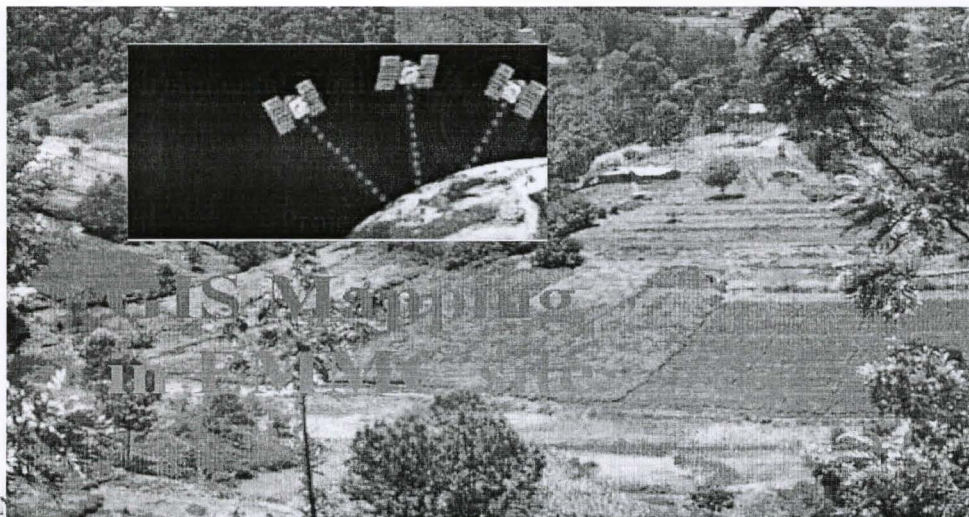
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1.0 Overview: FITCA Project.

The regional project FITCA (Farming in Tsetse Controlled Areas) has a general objective to integrate tsetse control activities into the farming practices of rural communities such that the problem of trypanosomosis can be contained to the levels that are not harmful to both human, livestock and environmentally gentle and integrated into the dynamics of rural development and are progressively handled by the farmers themselves. The project is hosted by the Inter-African Bureau for Animal Resources of the African Union (AU-IBAR) and covers areas with small scale farming in Uganda, Kenya, Tanzania and Ethiopia.

EMMC (Environmental Monitoring and Management Component) is the environmental component of FITCA. It is implemented by ILRI in collaboration with CIRAD (as member of SEMG, Scientific Environmental Monitoring Group). This regional component has been charged with the responsibility of identifying monitoring indicators and methodologies, as well as the development of an environmental awareness among the stakeholders. It contributes to propositions of good practices and activities mitigating the impacts and rehabilitating the threatened resources likely to result directly or indirectly of tsetse control and rural development.

The FITCA EMMC project was written by Dr. Robin Reid of the International Livestock Research Institute (ILRI) a future Harvest Centre supported by CGIAR (Consultative Group for International Agricultural Research).

The present report has been prepared under the responsibility of the leading group of EMMC:

Dr Bernard Toutain, Agronomist, coordinator.

Dr Joseph Maitima, Ecologist.

1.1 Overview :EMMC

Introduction

Control of trypanosomosis increases the efficiency of oxen so those farmers can plough more land in areas with low compared with high disease prevalence. In many cases, control of animal trypanosomosis acts as a magnet for human migration. People move to new lands after they are freed of the tsetse fly.

If this disease is controlled, there are almost certainly environmental consequences resulting from the expansion of cultivation and livestock numbers, such habitat loss and species extinction, a net release of CO₂ to the atmosphere and loss of vegetative cover that protects soil structure and fertility. Farmers often burn vegetation in the process of clearing land, which further releases harmful greenhouse gases. Land cover changes can also affect regional-scale hydrology and climatology.

These general environmental concerns apply to the specific project areas in the different countries as follows:

In Kenya and Uganda, much of the proposed project areas are already densely populated. The landscape is heavily used for agriculture and the potential for further agricultural expansion is limited. However, there are other small patches of vegetation that people have avoided using, principally because of the threat of contracting diseases. These areas, which experience low use, include riparian corridors, swamps and wetlands. These are the very habitats that are richest in species and can become overused when the constraint of trypanosomosis is lifted. These areas will be one of the first focuses of the environmental monitoring (environmentally sensitive areas) of indirect impacts at the Kenyan and Ugandan sites.

"Monitoring of project impacts needs to feed directly into strengthening the ability of communities to take action to sustain their natural resources. Without this connection, monitoring has no impact on the rural poor. A series of techniques have been developed to involve communities in monitoring and to empower them to better manage their natural resources. The overall objective is to increase the sustainability of natural resources and agricultural systems, through environmental monitoring and management, in participating FITCA countries. The twin objectives of increasing productivity to improve human welfare and to sustain those gains over the long term are at the core of the objectives of the agricultural sector in each country.

The EMMC project purpose is to increase the level of information and awareness of environmental change and increase the capacity to respond proactively to these changes among stakeholders in FITCA participating countries."(EMMC Report 2002)

To reach the goals assigned to EMMC, a useful tool would be an information system able to store and manage the information describing the changes in tsetse flies and trypanosomosis challenges, control measures and landscape. Because local communities would be both an information source and the main users and recipients of this system, they should be deeply involved in its design, and information returns should match their

needs. This latter point is crucial to ensure the sustainability of the information system after the end of FITCA programme.

This brief consists of a summarized introduction, maps depicting the project area, the methodology used in conducting the 2004 survey, a comprehensive analysis of land use changes since 2002 in the pilot survey area and statistics indicating the actual changes observed from the field survey.

2.0 Introduction to FITCA projects

FITCA Kenya selected to work in Western Kenya in only five districts which include Busia, Teso, Bungoma, Bondo and Siaya. Western Kenya is a densely populated area. Agriculture is the main activity in this region. Farmers produce cereals, cassava, pulses for consumption and local market, sugar, tobacco and pepper as cash crop.

This region has in the past been seriously affected by animal trypanosomosis and now rarely by sleeping sickness. FITCA -Kenya project started in 1999. It promotes the participation of farmers to tsetse control activities through adoption and self-use of two major techniques:

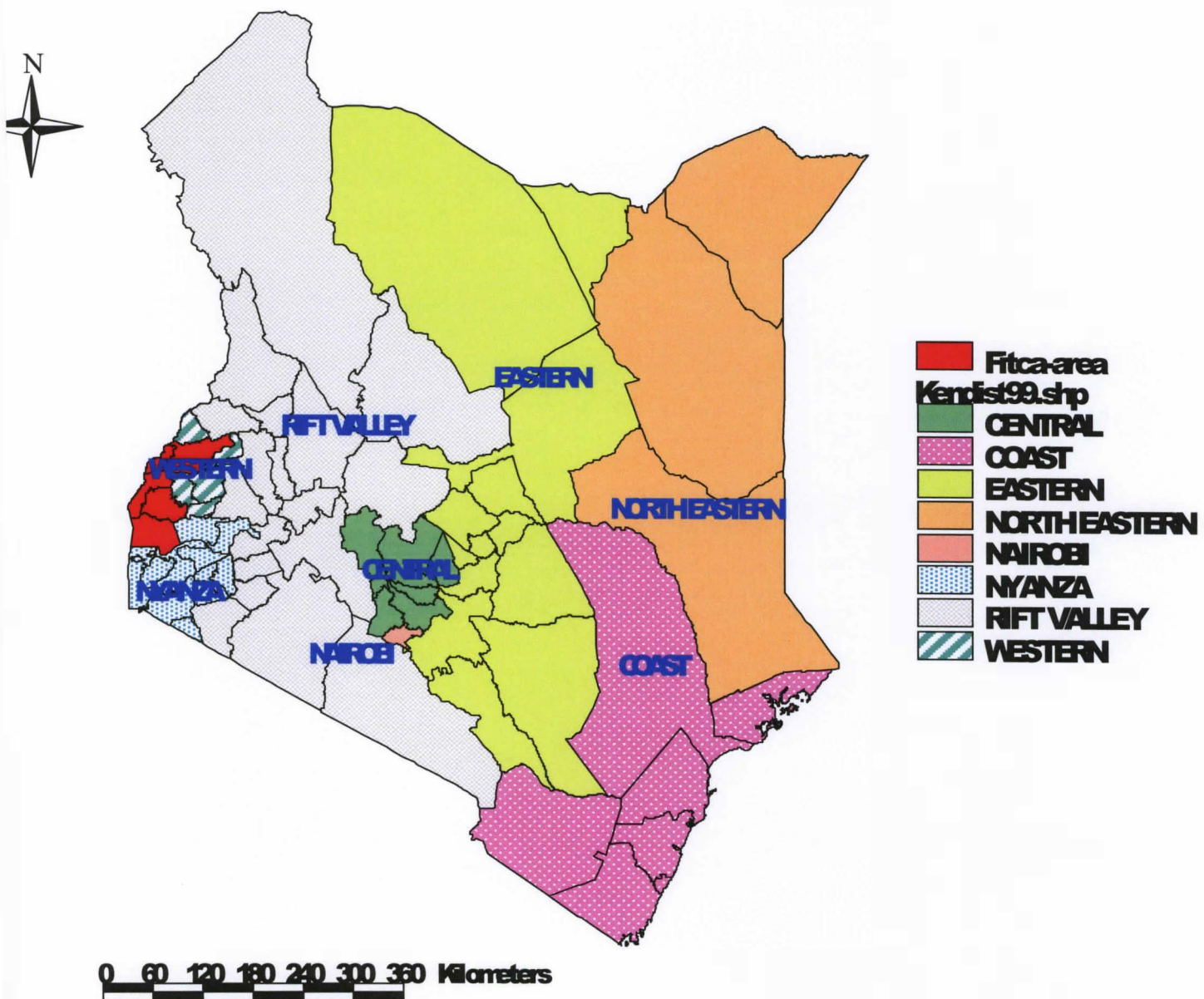
In dairy production, the use of impregnated permanent nets around the barns where the dairy cows stay. Two hundred farmers have been identified and receive convenient material, insecticide and extension service.

In non-dairy livestock rearing areas cattle are impregnated with insecticide by spraying in a crush pan. These are like living targets, able to poison the flies.

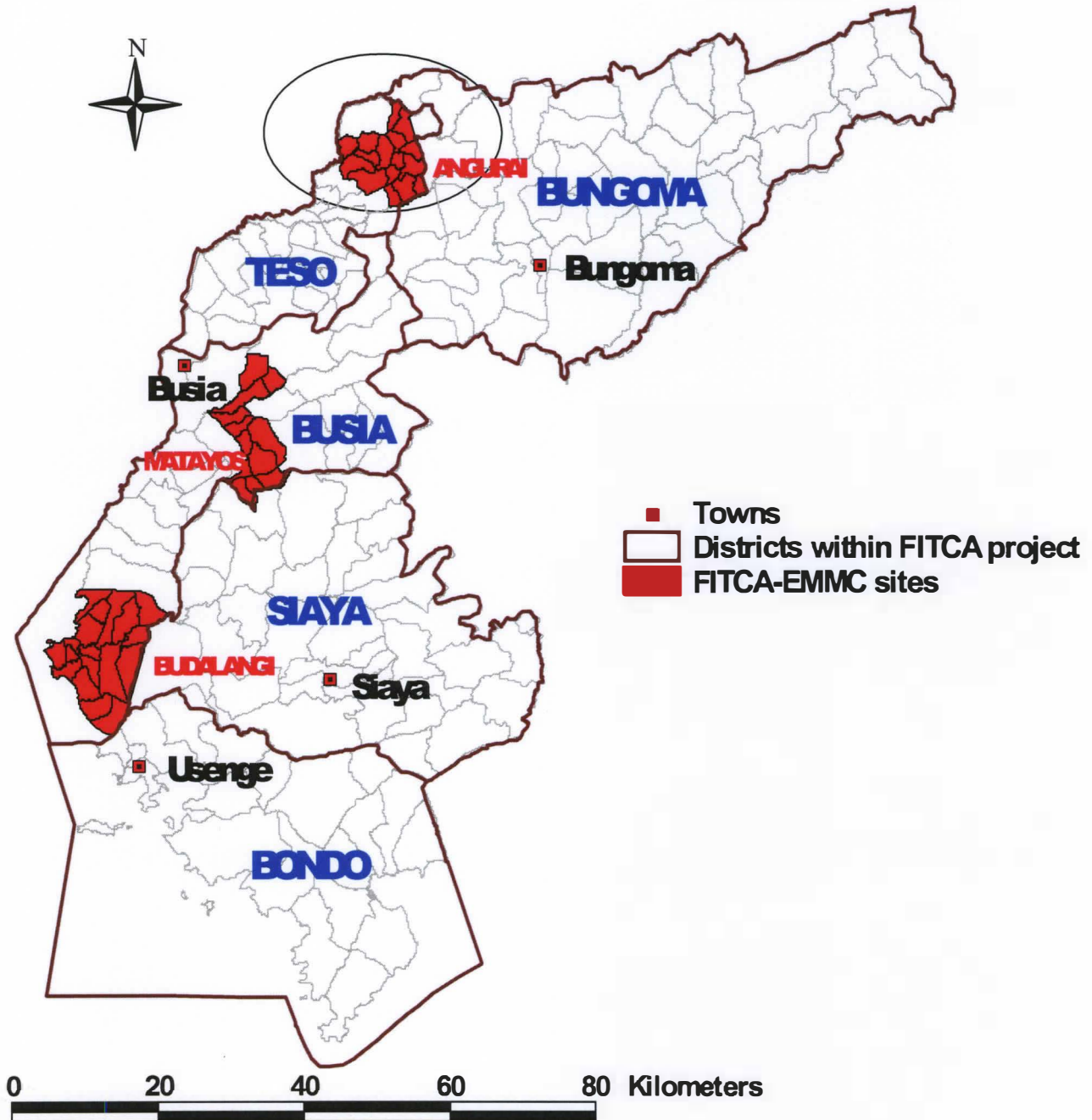
Field observations in Angurai location (Teso district, Kenya) strongly support the hypothesis of an animal trypanosomosis epidemic with severe mortalities (87% animal losses according to statistics of the livestock services).

This study is designed to detect land use changes that occurred since the last mapping exercise conducted in 2002.

Map 1: KENYA EMMC Sites



Map2 BUSIA EMMC SITE



2.1 Angurai: Basic information

Teso district's altitude ranges from 1300m above sea level in the south to an average of 1500m in the central and northern parts (Katotoi village in Angurai division is in the northern part of the district). There are several hills rising above the general level. The topography is undulating with hilly terrain in some parts (Government of Kenya, 1997-2001).

Katotoi area of the district is characterised by numerous bushes of *Lantana camara* that grows as fallow in abandoned farmlands, roadsides and bushes along streams and river Malaba. These are known tsetse habitats and are expected to reduce due to increased cultivation and grazing.

The population of Teso district as given in 1989 population census is 126,584. With a population growth rate of 3.5% per year, the population was projected to rise to 167,487 in 1997 and to 192,656 in 2001.

Owing to the elevation of Teso to a fully-fledged district, it's expected that rapid growth rates are likely to occur in the future as more people from outside the district will settle to work or carry out business ventures.

The population of Teso district is evenly distributed with large concentration in the main centers like Malaba and Amukura.

Among the four divisions of the district (i.e. Amagoro, Amukura, Angurai and Chakol), Amagoro had the highest population density (413 persons/km²) in 1997 projected to increase to 475 persons/km² in 2001. The divisions with low population density are Amukura followed by Angurai (Government of Kenya, 1997-2001).

The Northern zone in Teso district is hilly and densely populated. The Katotoi region of the district is under urgent trypanosomosis control because of the high density of tsetse. In this region, animal diseases (mainly trypanosomiasis) seriously reduced the livestock numbers. Following FITCA intervention the use of traps and targets has reduced the tsetse density. This was selected as one of the EMMC sites given the attributes described in the overview.

Map 1 depicts the location of Teso district in Western Kenya while Map 2 zooms to the location of Katotoi EMMC site.

3.0 Objective of GPS mapping

The objective of Environmental Monitoring and Management Component (EMMC) is to develop an information system and methods for monitoring the direct and indirect effect of farming in tsetse controlled areas (FITCA). One way of monitoring is through surveying and mapping using available methods for change detection especially on land use land cover over time. Maps were created using GPS ground survey.

The main objective of GPS mapping is to capture the area and the distribution of various land use land cover at farm level. This provided the required baseline indicators of land use change for the monitoring and management purpose. The information was also used in training and classification of high-resolution Spot 5 satellite images for mapping the wider EMMC and FITCA study areas.

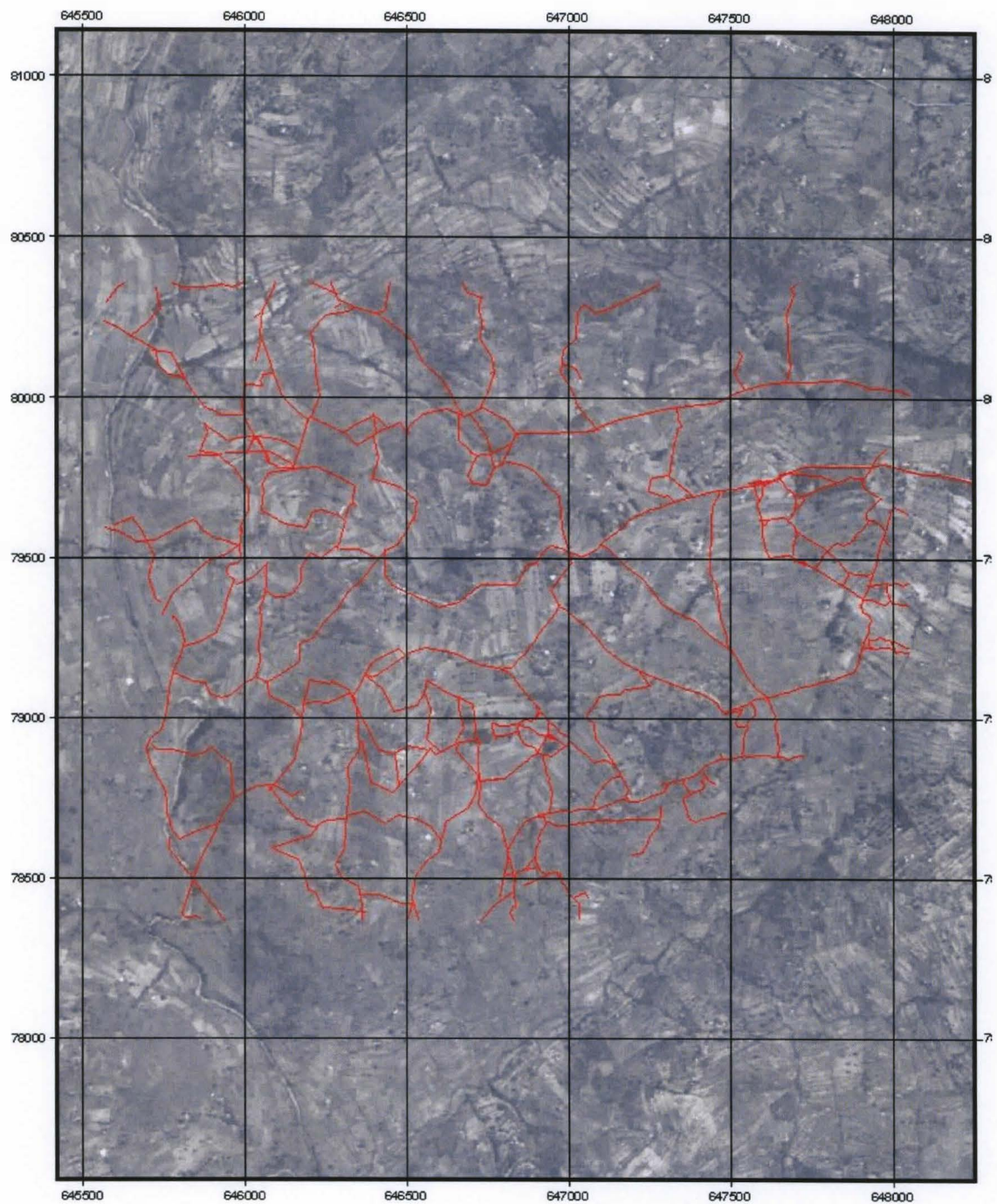
Ground survey techniques are time consuming and laborious but one is able to capture all possible land phenomena's from the social economic using questionnaires, land ownership using cadastre survey to land use land cover at farm level using GPS.

The Pancromatic and Xs version of Spot 5 image whose pixel resolution is 2.5 by 2.5 meters was acquired through programming by the CIRAD remote sensing expert Figure 1 and 2. This was used to train and extrapolate from the GPS pilot survey area of 2 by 2 km to the greater district/region to get the "big picture" phenomena of the project impact for the entire scene of Busia/Teso covering 16km by 16 km. The use of satellite provided useful information on the baseline landforms such as interfluvies, glacies and uplands which are difficult to discern using GPS survey.

The Satellite image acquired in May 2004 was difficult to use in ground validation as the seasonality of land use militated against ground crop identification. The image was however extremely useful in establishing Ground Control Points (GCPs) that were essential in geo-referencing and elimination GPS shifts during analysis.

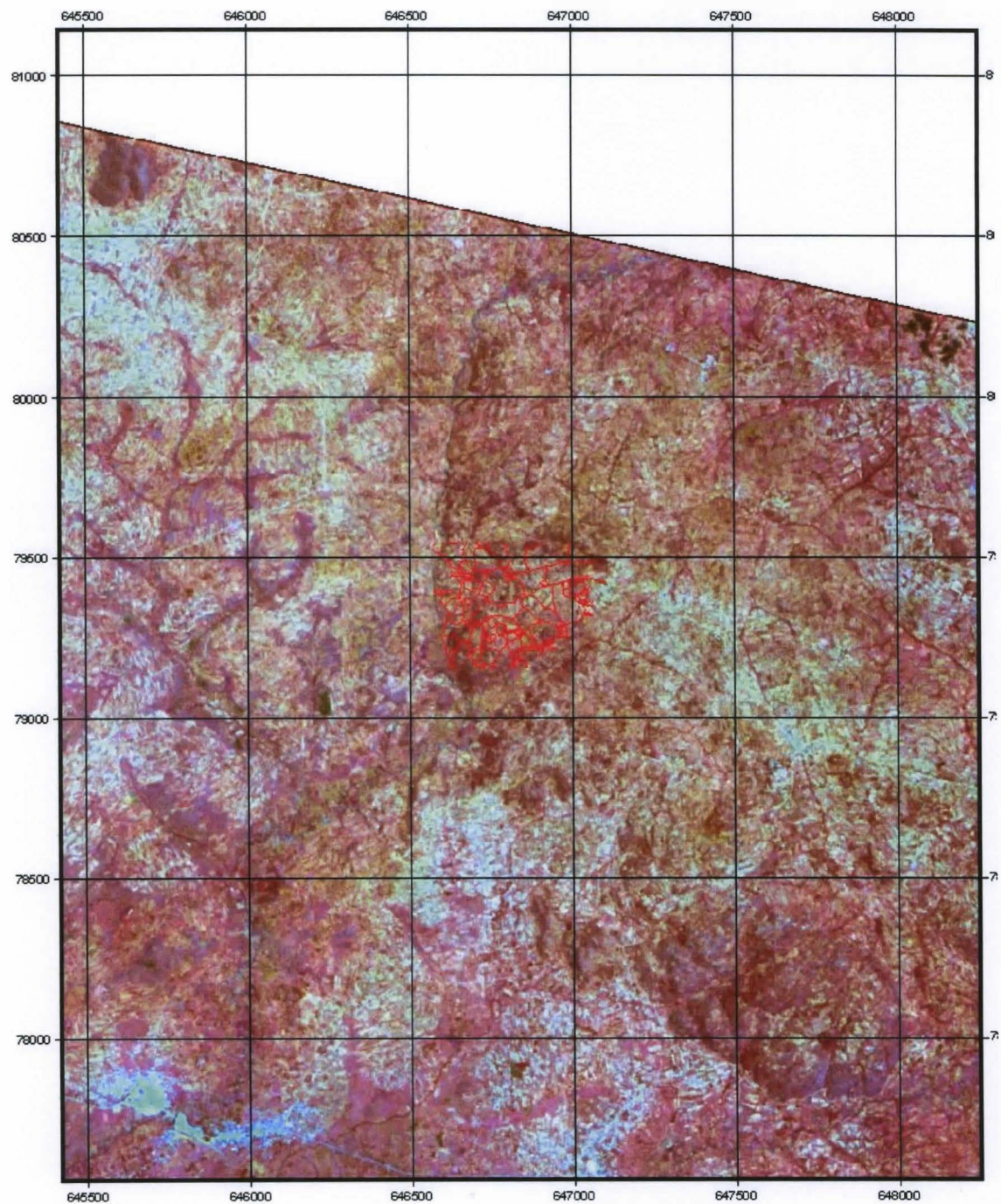
The Panchromatic version was essential in establishing road based control points especially at road intersections. This were concurrently captured as geo-events using GPS and upon downloading and overlay, the align tool in arc view software was used to correctly geo-reference the geo-events.

Figure 1 Angurai Spot 5 Pancromatic image



Spot 5 Angurai P-Image

Figure 2. Spot 5 color image of project area



Spot 5 Angurai XS-Image

3.1 Accuracy: GPS vs. Spot 5 satellite image.

The 2.5 M Spot 5 satellite image was consistently more accurate relative to the GPS point readings. The GPS Estimated Position Error (EPE) ranged from 4 to 7 meters depending on the geometric position of overhead satellites. This was a much error higher relative to the Spot 5 image. It was concluded that high end GPS equipment with sub-meter accuracy would have been ideal to authoritatively establish GCPs for the Spot 5 satellite image.

3.2 Methodology used.

GPS mapping methodology follows specific steps and processes, which can be summarized as; Preparation in terms of logistics and tools required, staff recruitment for fieldwork, field training, fieldwork organization, data collection and storage (tracking and downloads), data editing and treatment in pre and post field operations, data analysis, generating statistics and map production. This report describes in details these practical steps.

3.2.1 Preparations and logistics

Contact person and Study sites

The EMMC study sites had been identified for detailed land use / cover survey and mapping within the areas covered by FITCA project. Identification was by assessing ecological sensitivity of sites based on potential impacts likely to occur as a result of tsetse control (EMMC Annual Report 2002). The contact people were the district FITCA project leaders who are based in Busia.

3.2.2 Sensitization

Preparation for fieldwork involved a lot of communication and arrangement between the contact persons and the office. The contact persons have to be informed of the exact dates of operation and site location at least one month before. This gives them ample time to inform the administrative hierarchy from national to the village level. Ground mapping involves direct interaction with the local community who are the owners of land resources being mapped. People at the village level where actual work will be done needs to be sensitized on the work to be done so as to clear any mis-understanding that might arise. Land is a very sensitive asset to the farmers. A major mis-conception by farmers during field mapping is that people are surveying their land for some ulterior motives. Such issues should be clearly explained to farmers before hand for smooth running of the fieldwork. Most of this sensitization is arranged and done through the contact person. Part of the explanation is also done during the fieldwork through local villagers hired as field guides.

3.2.3 Recruitment

The fieldwork is normally headed by the project supervisor who is also the project ecologist mainly involved in the vegetation survey exercise. The GIS analyst who co-ordinates all the work dealing with land use mapping and manages all the data collected in the field assists the ecologist. The contact person arranges and recruits the required local field assistants for GPS mapping, vegetation survey assistant and the field guides.

The general requirements for GPS mapping assistant is education level of at least form IV who is able to communicate in English and the local language. The person should also be physically fit since the work involves a lot of walking for long hours and in difficult terrain. Young school leavers waiting to continue with their education or looking for a job were targeted by the area chief for the GPS survey training. This group is eager to

learn and they are satisfied with the per diem provided. A field guide assistant should be somebody well known in the village (an elder) that is able to communicate to the people information about the exercise and also knows the village geography so as to guide the others involved in the work. Recruitment is open to both women and men. Eight people were required for GPS mapping, one person to assist in vegetation survey. Three field guide assistants were deployed during the 2004 survey; they were used in vegetation survey, GPS analyst guide and one partially used to assist the only female recruit survey in dense vegetation with wild animals. This field guide was not trained in GPS techniques, but would be requested by the female assistant to walk along cliff and difficult terrain with the GPS capturing the data in continuous digitizing mode.

In vegetation survey a field botanist was recruited to assist the ecologist in identifying and classifying the plants.

3.2.4 Accommodation

Accommodation was arranged for none local staff within the nearest town to the study sites (Malaba). The hotel identified was secure and though electricity supply for operating the electronic tools required for fieldwork e.g. computers was very erratic.

3.3.0 Field operations

Transport

Transportation is a very important factor in this work. Used to transport field staff from the hotel to the site and also within the site. A reliable 4 wheel drive vehicle is essential to enable mobility over extremely difficult terrain. The leader of GPS mapping was in required to move and assist those with GPS machines problems. Field assistants would send a SMS telephony message giving their exact location coordinates, enabling the GPS leader to use the GOTO command on the GPS to locate the distressed assistant and offer necessary technical assistance.

3.3.1 GPS machines and accessories

The main tool used for this mapping activity is a hand held Global Positioning System machine (GPS). The available make used are GARMIN systems both model CX and XL. The CX model has a storage memory double that of XL and stores 1000 waypoints and 2056 track points. It is advantageous to use the CX model due to the superior memory capacity. One is assured of working for the whole day without requiring data download to a computer to release the memory. This is important because downloading at the site is cumbersome and time wasting. It is much better to do it at the end of the day.

Hand help GPS run on 4 normal AA size batteries. In this work a set of 4 would run a machine for two days. Depending on the number of machines and the number of days enough high quality batteries should be purchased to last the whole fieldwork duration.

The accuracy of a GPS depends on how good it is receiving signals from the satellites. If the GPS will be used inside a car then it is necessary to have an antenna for better reception. When working in the open field an antenna is not required. But is good to have one just incase you might need to track something like a road while being inside a car.

A data download cable is a must for GPS land use mapping. As explained above the memory of a GPS is small and data must be down loaded to a computer at least once in a day. It is important to make sure you test the compatibility of the cable and the GPS machines that are available and the computer to be used before going into the field. It is also advisable to have at least two cables just in case one gets spoiled.

3.3.2 Common Technical problems

GPS Initialization.

Some GPS machines due to age malfunctioned during initialization. The inability to lock to satellites often resulted in distress calls from field assistants. This was rectified through conducting a cold boot on the GPS.

Loss of battery power after a short time.

Normal AA size Duracell batteries should last 2 days, however many assistants would complain of loss of battery power after four hours. This was attributed to using the backlight accidentally which consumes power relatively fast.

GPS Overheating.

Some assistants complained of “GPS overheating”, this was caused by high local thermal conditions that necessitated GPS internal cooling system to be activated. This produced a hissing noise that resulted in panic from assistants.

GPS blackouts

Assistants complained of unexplained failure by the GPS in which the power would turn off automatically. This fault was traced to poor battery support. The movement by the assistants had the effect of disconnecting the power circuit; this was solved by placing buffers around the batteries.

3.3.2 Computer and accessories

Computer hardware and software are required for this mapping work. A laptop machine is the most ideal and convenient. It should have the required devices such as external drives for backups. The machine should also have compatible ports (serial, parallel, UHB) for connectivity of peripheral devices. The devices to be considered in this particular work are the GPS and the download cables, printers and also Digital camera if available.

Software tools are as important as the hardware tools mentioned above. This being a mapping exercise a desktop GIS is required. This must be compatible with other software used for the ease of data transfer and management. Common desktop GIS software used is ArcView from ESRI for viewing the spatial data and producing maps, which can be inserted in documents or printed out as hard copies. The capability of producing maps is important in this exercise since they are used for reviewing the progress of mapping work and identifying any errors that might occur in the mapping process.

Another important software is a GPS data download interface into the computer. This software should allow one to save the downloaded information in a format that is compatible especially with the GIS systems. In this work, the software used is called OziExplorer. It is compatible with ArcView and can save download GPS data directly into shape files for ArcView manipulation.

Apart from data download, the software should allow for data upload from the computer to the GPS. This is a very essential operation especially when delineating work station for field staff. To avoid overlaps between adjacent field assistants, the polygon delineating the actual area to be covered is uploaded into the GPS using the “Upload to GPS module” which is then used to guide land use mapping.

This was very essential in areas which lacked unique land based physical features eg rivers that were used in delineation of workstations for field assistants

Laptops normally run on electricity as well as on a battery. Most laptop batteries can last between 2 to 3 hours when they are fully charged. If one is not doing much downloads on the site then one battery would be enough else it would be advisable to have a spare battery for proper power backup.

The palm top is more versatile and is recommended in lieu of the laptop. The palm top is easily portable and has a much shorter initialization time. Files are saved using the palm

based Ozi explorer CE. These are directly converted to shape files for use with standard GIS software.

Palm tops also have the advantage of longer battery operational time with approximately 8 hours of continuous operation when fully charged. This is more superior to the 3 hours lap top operational time. The palm top can also allow the upload of a base map for the survey area, and with the use of the GPS real time tracker, one is able to see their exact GPS location in relation to the base map. This is very essential when mapping dense vegetation like forests where one can lose their sense of direction when using the GPS alone.

A printer is also required for this type of fieldwork. It is mainly used for producing maps that assist in making a day working strategy and monitoring. There are small portable ink jet printers (different makes) that are very ideal for this work in the field. One should also not forget the ink cartridges and the required connecting cables.

It should be stated here that a computer plus the mentioned devices is a must since all the information collected in a day will have to be analyzed for monitoring the work progress and must be backed up due to the storage limitation of a GPS.

3.3.3 Stationery

Stationeries required for this exercise include pens, pencils and rubbers, writing pads, clipboards and printing papers. Enough data recording sheets should be prepared before the fieldwork starts. The data sheets include; GPS recording forms, Vegetation recording forms and the social economic household survey questionnaires (see attachments).

3.3.4 Communication in the field

Communication among the surveying and mapping group members is very important. Where mobile phone systems are available they are the best means for communication. This is more so between the GPS mapping members who work in different and far apart areas. At times one might encounter very simple problems with the GPS machine and through the phones this might be sorted out very easily. Also if one needs to move and assist or be assisted in a major problem one is able to communicate with the driver to be picked in a specified position for transportation. Hence communication using mobile phones should be facilitated as an essential requirement in this mapping methodology.

The other even more effective method is to use GPS with communication radios. The Garmin Rhino 110 model offers this functionality in addition to undertaking the standard functions performed by the Garmin 12 XL and CX versions. They have the advantage as they can be configured to communicate over a 50 kilometer radius. Mobile phone,

though useful proved ineffective in Angurai as the only Kencell network was available in some sections of the survey area.

Other tools

- First aid Kit
- Measuring tapes
- Panga
- Polythene papers for holding soil
- Bucket for mixing soil samples
- Poles and pole clothes for demarcating vegetation plots and quadrants

3.3.4 Budget

The budget depends on the number of days required for fieldwork and the distance to the study area. The table below gives an indication of the costs involved in 10 days mapping and surveying work.

Table 1: A sample budget for a 10 days fieldwork

Item Description	Number	Unit cost Us \$ (* 10 Days)	Total Cost US \$
Ecologist	1	1,100	1,100
Sociologist	1	1,100	1,100
Botanist	1	410	410
GIS Analyst	1	1,100	1,100
GPS Assistants	6	70	420
Field Guides	3	30	90
Drivers	2	550	1,100
Stationery		100	100
Transport		1,500	1,500
		Totals	6,920

3.3.5 Field work organization

The fieldwork schedule can be divided into the following phases; travelling, initial training, data collection and verification. It is important to verify that all the required tools as enumerated above are available and they are in working condition. A sufficient amount of stationery and other consumables should be availed, as it is very difficult to purchase them in the field.

3.3.6 Training

Introduction

After traveling to the study site the first two days are reserved for training the recruited staff on the application of GPS in mapping, familiarization of the study area and the local community. The contact person should be able to organize for a room where training can be conducted for the two days.

The main objective of GPS training is to enable the trainees to use the machine for recording waypoints and tracking of poly lines to define various land use land cover types at farm level and coding. It is not the intention of the course to go into the complicated concepts of GPS systems. By the end of the training the student should be able to manipulate and capture spatial data using the system. To most trainees, it is usually their first time to see and use a GPS system. It is important to start from the simplest concept of operating the system such as switching on and off, replacing the batteries and scrolling between different menu systems of the GPS pages.

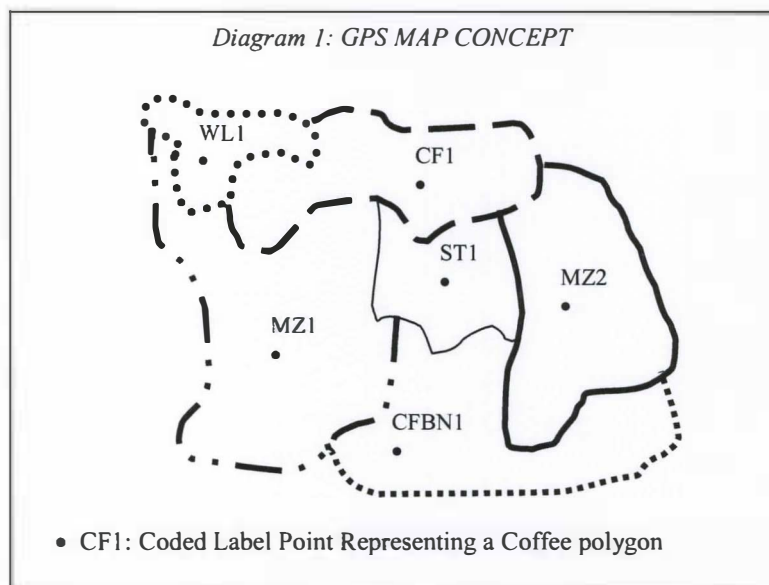
Training module

1. Introduction to GPS system (Space, ground, and user segments)
2. Uses of GPS and future direction of industry
 - Current uses
 - Development of Galileo gps system
3. GPS maintenance operations
 - battery changing
 - Connection of external antenna
4. GPS configuration
 - System configuration
 - Mapping configuration (map datums and reporting format)
 - Download configuration
5. Mapping quality control
 - Observation of EPE and satellite chart.
 - Identification of gaps and missing unique identification waypoints

-Deletion of previous work to avoid overlaps

3.3.7 Map Concepts

The concepts of mapping should be introduced in the simplest terms possible. This should be explained in terms of a polygon which defines a land use boundary (Track) and a polygon label point, which describes the land use class or type (Waypoints) (Diagram 1). The



trainees should understand the GIS concept of data storage where tracks that overlap do not need to be tracked (Digitized) twice. These saves time, GPS memory space and reduce the work required in data editing at later stages.

General GPS Manipulations and setups (GARMIN)

There are many different types of GPS systems in the market but the basic principle of GPS system operations is the same. In this particular work GARMIN GPS systems were used. It is important for the trainee to understand some of the basic operations and setup required before practical application of the system. This includes

- The buttons that are used to manipulate the GPS, which includes the switch for on and off, waypoint marker, Enter key and the scroll bar buttons. The battery pocket and how to replace batteries, the antenna and the data download ports should all be demonstrated to the trainees.
- Observing the estimated position error (EPE) on the GPS satellite page that measures the accuracy of the GPS recorded position depending on how well it is receiving the satellite signals. One should start using the system when the EPE is within the acceptable ranges, which in this case we had set it to 5 meters. This implies that the positional accuracy is within ± 5 meters of the true location. The setting of contrast for better visibility should be demonstrated. It is a common mistake to find the trainees complaining about the failure of the machine only to find that the contrast has accidentally been set to zero. The user should also be able to view the battery level meter so as to know when to replace the batteries.

- The navigation system should be set depending on the user's requirement. This includes position coordinate system that could be degrees, UTM and many others. The map datum, Download interface and other relevant map parameters should be set accordingly.

- Knowing how to read the position co-ordinates is important. One should be able to differentiate the x and y coordinates especially when they have to be recorded on paper.

Example 1: GPS setups (GERMIN)

```

Setup Menu
System
    Normal Operations
    Offset + 3.00 hrs
    Contrast
    Tone
Navigation
    Position format UTM/UPS
    Map Datum (arc 1960)
    Units (Metric)
    Heading (Auto)
    Interface GARM/GARM
  
```

Understanding system manipulation technique improves the speed of doing work and production of accurate map data.

Tracking, recording way points and coding

This is the main area of training because it is through this process that one is able to capture data required for land use land cover mapping on the ground. The process involves identifying the class type and the estimated boundary, walking around it with the GPS on and recording or tracking the path that defines the polygon, recording a waypoint in the middle of the tracked polygon and assigning it an identifying code (label point) using the agreed coding system.

Tracking

In a GARMIN GPS system the tracking setups and manipulations are performed within the map drawing page. The time interval for recording is set once depending on the average sizes of land use polygons to be mapped. This can vary between 5 and 10 seconds where the larger the polygons the higher the time interval should be set. Under the track set up option one is able to start or stop the track recording process by setting the recording option to ON or OFF respectively. One is also able to observe the amount of memory used and the amount remaining.

Example 2: Track set up options

```

Record: {FILL | OFF}
Time interval: HH MM SS
               00 00 05

Memory use: 20 %
  
```

Waypoint

After tracking a polygon a waypoint needs to be recorded inside the polygon to identify the land use type. There are two ways of recording a waypoint inside the polygon; one can walk inside and record a way point somewhere within the polygon or you can use the PAN technique to scroll your map such that the position marker appears in the middle of the already tracked polygon. The PAN technique is important especially when there is no

accessibility into the polygon e.g. when mapping a thick bush or a fenced and inaccessible compound. The PAN technique is also advantageous since it reduces the distance one has to walk by not having to walk in the middle and out again for tracking the next polygon. Whichever method is used a way point is recorded by marking inside the polygon.

Coding

The purpose of having a waypoint in a polygon is for identifying the type of land use within. A way point will be meaningless if it is not properly coded using an agreed system that make sense to the people concerned. In this method a coding system of all possible land use types has been developed which uses two letter codes (*See Appendix A*). Where there is a mixture the two main cover type codes are used starting with the dominant one then followed by the second code. As an example the following are codes used for various crops Maize-MZ, Coffee-CF, Bush-BS, Banana-BN, Woodland-WL, and Homesteads-ST. Hence a mixture of coffee and banana will be coded as CFBN. Since duplicates are not allowed when coding in a GPS, land use and cover types should be coded with a sequentially assigned number such as MZ1, MZ2, MZ3, CFBN1, and CFBN2 within a days session. The sequential coding can be repeated again after the data has been down loaded and deleted from the GPS. The coding system is limited to a maximum of six characters (alpha-numeric) as dictated by the GARMIN GPS waypoint name.

After assigning the correct code (name) to a waypoint it is finally saved and can be viewed on the GPS map page. The coding information saved in the GPS is also recorded manually on a pre-designed waypoint data form (*See Appendix B*) with the full description of the code for reference during data verification and editing at a later stage. The date, the number assigned to the GPS and the name of the user are also recorded on the data sheet.

This process (tracking, waypoint recording and coding) is repeated again and again for every polygon that is to be mapped. The trainees should be made to practice this process as many times as possible until they perfect it. Else without mastering it no proper work will be accomplished.

Field Practices

The training also involves field practical in the second day when the techniques learned in class are practiced and perfected. The process starting and stopping the tracking of a poly line, recording around corners by having a short pause to have smooth corners and finally recording and coding the polygon label points are demonstrated and practiced in the field.

During practical training, the possible land use types are identified and clearly described and agreed upon by all so that classes are mapped and coded the same by everyone. Any new unique land use types are also identified and given new codes. The trainees are also

allowed to come up with new codes when they encounter new cover types but it must be recorded quite clearly on the data sheets.

3.3.7 Common mistakes and errors

There are many common but very serious errors that are encountered and it is important to mention some of them here;

- **Forgetting to Stop tracking at the end of a polygon**

Many a times is when the trainees forget to stop the track recording, which should be done by switching the track record to OFF mode at the end of a polygon. This results in recording many meaningless lines during the process of recording a waypoint. This also results in exhausting the storage memory within a very short time.

- **Duplicating codes**

As explained above a GPS does not allow duplicate codes, but at times trainees forget to record codes on their data sheets leading to them trying to use the same code again, which is rejected by the system. The tendency is to think there is something wrong with the GPS. This issue of duplicate codes should be emphasized.

- **Changing record interval by mistake**

This happens and it can be very frustrating. If for example the set time is changed to one hour, this means that a single vertex of a track will be recorded after one hour. The logical conclusion is that the GPS is faulty and is not recording tracks. The other possibility is when it is changed to less optimal values, it will continue recording but the polygons have very unnatural shapes with straight lines and sharp corners. Hence it is advisable to check the time interval set up when such problems are observed.

- **Undershoots and Overshoots.**

This happens when the trainees does not pay attention to the continuous mode digitization when tracking polygons. In many instances especially before the trainees gain confidence in the use of the equipment, polylines will be incomplete or will over shoot the original starting point.

This needs to be minimized as it increases post field editing work and affects the final work quality.

As explained in the training objective the aim is to enable the trainees assist in capturing land use and cover data for the purpose of mapping and deriving the relevant statistics. The training should achieve this objective, which can be verified by checking the type of outputs from the trainees. Usually they improve everyday and they are perfect toward the end of the fieldwork.

Data capturing and organization

After the first two days of training most trainees are ready to start working on their own. The strategy when organizing the group for data capture is to make sure that there will be no overlap and also no possibility of omission within the identified study area. The demarcation of areas to map should be based on tracks, paths, roads and other physical

features such as swamps and rivers existing within the study area. Such features should be identified and mapped where possible through the assistance of one of the recruited field guides. The mapping group leader should do this during the first day of working after the training. The exercise also assists the leader to familiarize with the study area and be able to organize, assign and monitor the mapping work.

Each GPS mapping group member should be assigned a separate area to map on the ground to reduce the possibility of overlap or omissions. Mapping leader should always be accompanied by one of the locally recruited field guides to act as the interpreter. This is important because although the locals are usually informed about the exercise before, one will always need to explain to the people you meet on the ground. The locally recruited staffs can move on their own since most likely they can communicate using the local or any other common language in the site.

Timing and communication

During the daily data collection exercise, it is necessary to arrange on how to contact each other in case of any problems. Communication through mobile phones is the best means where network is available. Else it is in order to arrange a central meeting point daily which should be located along the roads or tracks. The driver should facilitate the communication by being within reach from the agreed central point. On contact by one of the personnel, they can then look for the leader whose working location should be known by the driver.

The working hours are from 8am to 4 Pm without lunch break. This also includes travel time to and from the hotel. Through experience we realized that too much time is wasted in picking up and dropping back the workers when a common lunch is arranged. The practical way is for the workers to carry their own packed lunch and water which they can eat at their own convenient time.

Monitoring

Work monitoring and review by the leader is an integral part of the field organization and data capture. The leader takes part in the actual GPS mapping work but should also spend time to visit areas mapped by others. These visits are used to assess the quality of work being done and take any field notes required for data editing and analysis at a later stage. Maps are important products to use in the monitoring exercise. They should be prepared and printed at the end of the day and be ready before the start of the next days work. Mapping leader should be ready to work extra hours in the evening to download the data and prepare the maps. The maps should consist of the tracked polygons with the marked waypoint (polygon label and the corresponding assigned code or name used to identify land use type).

The maps assist in making the days working strategy in terms of work assignment and identifying the common errors and rectifying them. The responsible person through the guidance of the mapping leader should do the error correction. Maps also assist in

identifying sample areas to visit and confirm the type of classifications recorded. Field notes are also made on the maps for reference during data editing and correction.

Field Errors

Some of the common and most important errors and how they are made are as shown and described below;

- Missing label point

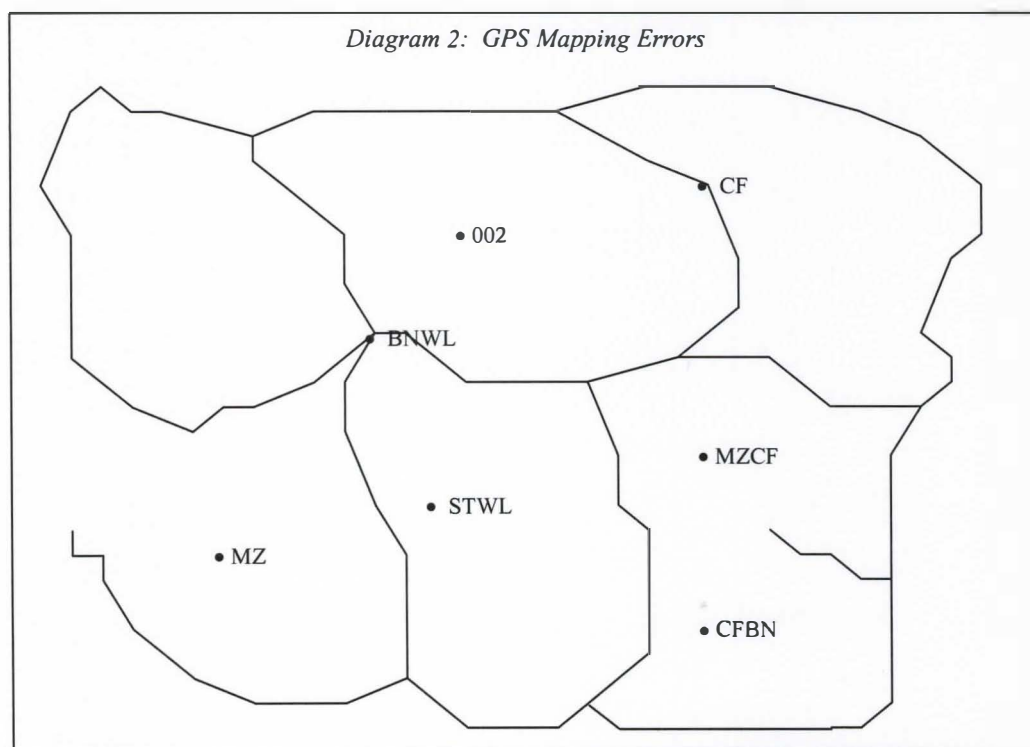
This happens quite often when one forgets to record a waypoint after the tracking of a polygon. It can also happen if one forgets to save the waypoint in the GPS after assigning the code.

- Misplaced label point

This happens when one forgets to walk or pan to the center of the polygon. Normally such misplaced labels will appear along the boundary in which case it is difficult to know where they belong.

- A none coded label

By default if a waypoint point is not assigned a code by the user, the system automatically assigns a code in form of a sequential number (e.g. 001, 002, 003....) to the waypoint. Again this should be pointed out and should be rectified by the user.



- More than one label

At times you find polygons with more than one label point and codes. Ascertaining the correct label code should rectify this

- Unclosed Polygons

These are polygons that are either not closed or the boundaries are not complete.

- Undefined Label codes

This is usually caused by typo error when assigning the codes.

At times one might find unusually big polygons, which must be confirmed. This happens when there are extensive land use types like maize fields or woodlands and it is important to check within such polygons since there is high possibility of lumping together other smaller land use that might be found inside.

In general it is very important to walk around the study area and confirm most if not all of the classified land uses and covers on maps and make necessary notes. The importance of having a portable printer for map production cannot be overemphasized. Without a printer one has to organize on how to print the maps elsewhere which might be very difficulty and time wasting in the mornings.

3.3.8 Data Download, Organization .

Data downloads from GPS to computer hard disk should be done at the end of the days work or on the site as soon as a GPS tracking memory is full. As explained earlier, the available software for download is called OziExplorer. The GPS and the computer software interfaces must be set for proper communication (*See GPS and software manuals*). A functional download cable is also required. It is only after verifying that data from GPS is properly saved that one can clear the GPS.

Downloaded data must be organized in such a manner that it is easily identified and related to the person (GPS) that mapped it. There are two related data set that are collected from the field using a GPS namely the tracks and the waypoints. Downloaded data is saved in the original OZI

Example 3: Interface Setup

OZI Setup

System

The GPS make (Garmin) 12XL or 12CX
Set up the Map datum
Set up the data and map paths

Maps

Country region (North & East SE)

GPS

Make Garmin 12x1 Symbols
Garmin Symbols

COM

Com Port (1,2,3, 4 or (5 UHB) port))
Parity none
Upload/download baudrate 9600
NMEA baudrate 4800

GPS Setup

format and also in GIS ArcView format for map production and data verification. Data should be saved in different directories to differentiate the waypoints from the tracks and between OZI data format and ArcView format. The file naming convention should be such that one is able to identify the GPS (user) used, the date, and the number of downloads in a given day. An example of file naming convention is tr-gp2-d22-1 implies that this file consist of tracks (tr) from GPS number two (-gp2) of data collected on date 22 (-d22) and was the first download (-1) of the day. The corresponding waypoint file should then be named wp-gp2-d22-1 carrying the same meaning as for the tracks. This kind of data organization makes data management very easy and eases the work of monitoring and advising each of the workers and data editing at later stages. Similar data organization is used for the household and vegetation survey GPS data sets. It is good practice to make backup of downloaded on daily basis just in case there is failure or loss of the computer being used.

3.3.9 Finalizing Fieldwork

One major objective before the end of fieldwork is to have a complete and continuous map sample of the study area. The final map product should not contain unmapped areas within the selected study site. This can be achieved through proper work assignment as guided by the results of daily monitoring of work progress in relation to the estimated total area of study site. The last day or two should be used for verifying the work done by the mapping group and completing unmapped parts of the study site. Verification maps needs to be printed out showing the coding of all the polygons to identify errors and taking necessary notes for data correction. At the end of the exercise it is important to make sure that all the recruited staff have been paid and have handed in all the data record sheets, which are also used as reference materials for data editing.

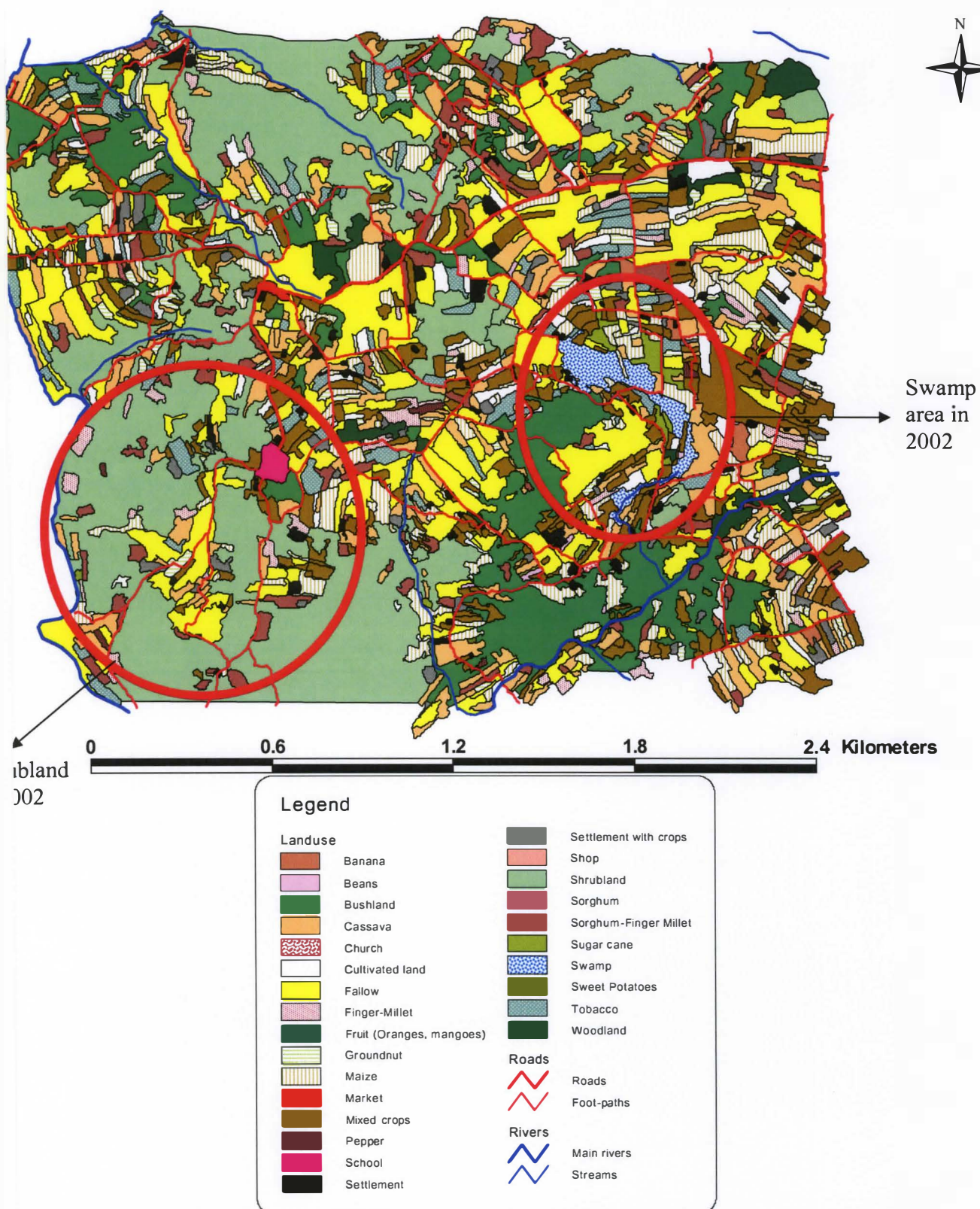
3.4.0 Comparison of the two mapping episodes

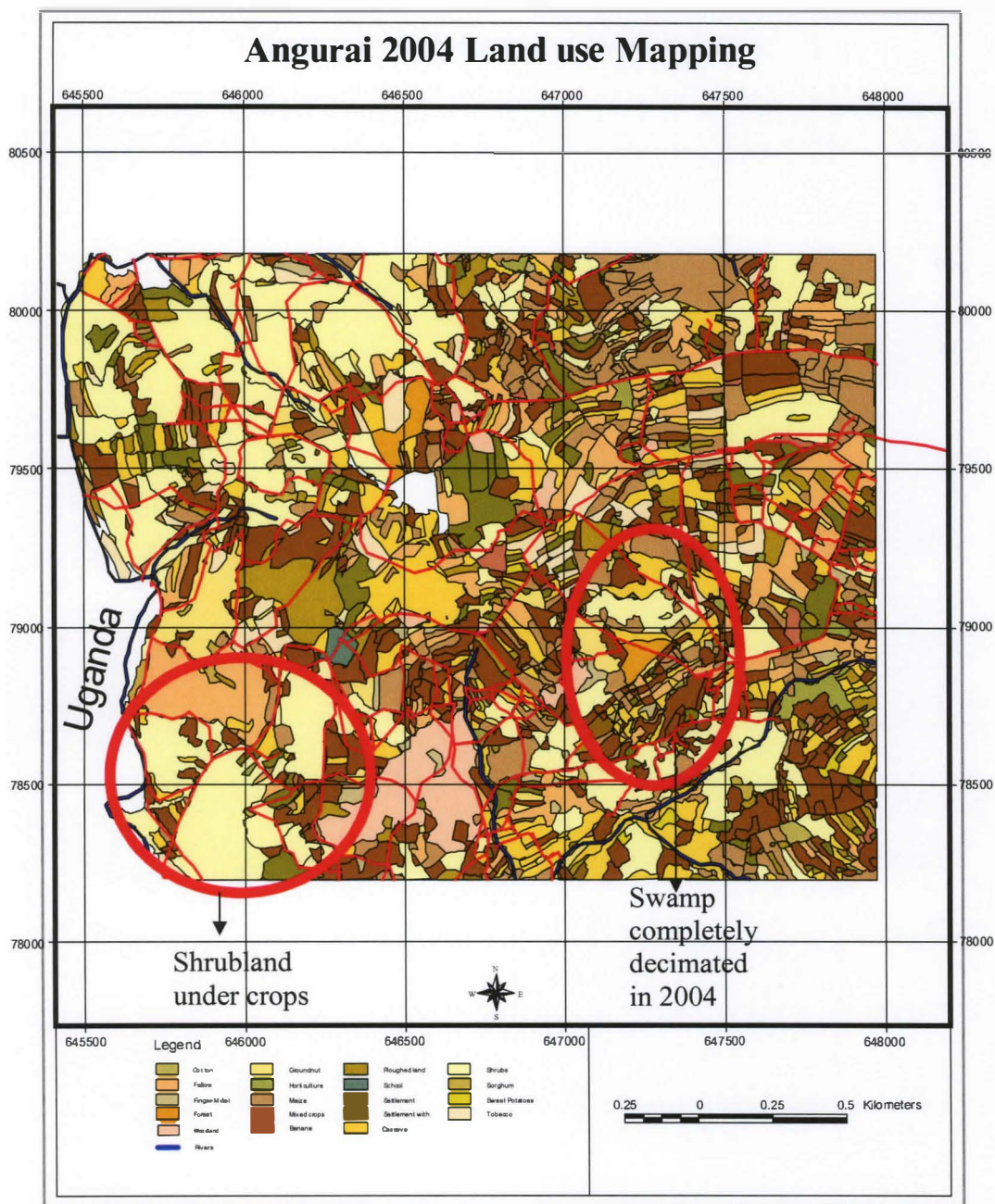
Pre-Survey reconnaissance mission confirmed that massive farming activities were taking place. However it was not possible to ascertain what type of farming predominated. The survey thus gives a quantitative analysis of the changes that have taken place since the last mapping exercise of 2002.

Prior to conducting the in-depth analysis, a visual comparison between the two shape files developed from respective surveys revealed that the swamp area was completely decimated and shrub land was under attack from all areas of the pilot survey site.

Footpaths that once formed mapping boundaries were often non existent having been eliminated during the ploughing of fields.

Map 4: Detailed Land use Classes Katotoi





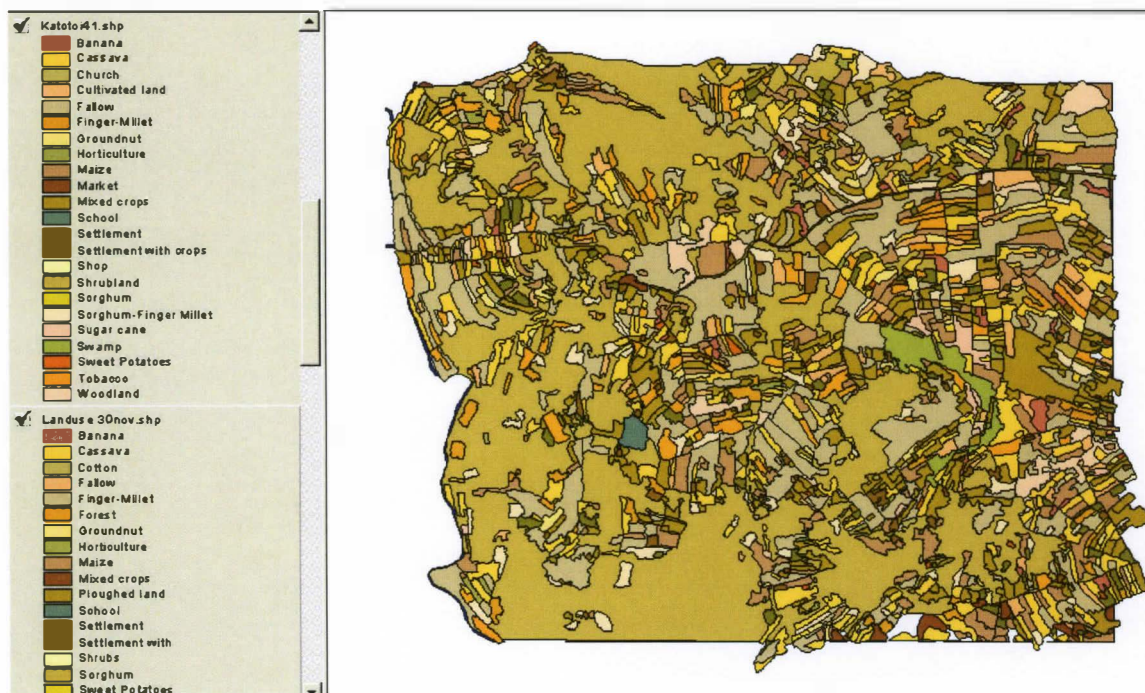
4.0 Change detection analysis.

4. 1. Method used in change detection

To effectively detect land use/ Land cover changes over the two mapping episodes the following procedure was followed

Selection of the Shape files compiled during the 2002 survey. This was overlaid with the Shape file compiled for the 2004 Survey. See fig 2.

Figure 2



Due to discrepancy between the two shape files with respect to commonality of the land use, the legend was harmonized to reflect similar land use naming conventions.

The Geo processor extension was used clip the 2004 files to cover the exact same areas as that of the 2002 survey.

The harmonized files were then converted to grid files to enable assignment of unique identification of the individual pixel values based on land use type. See figure 3.

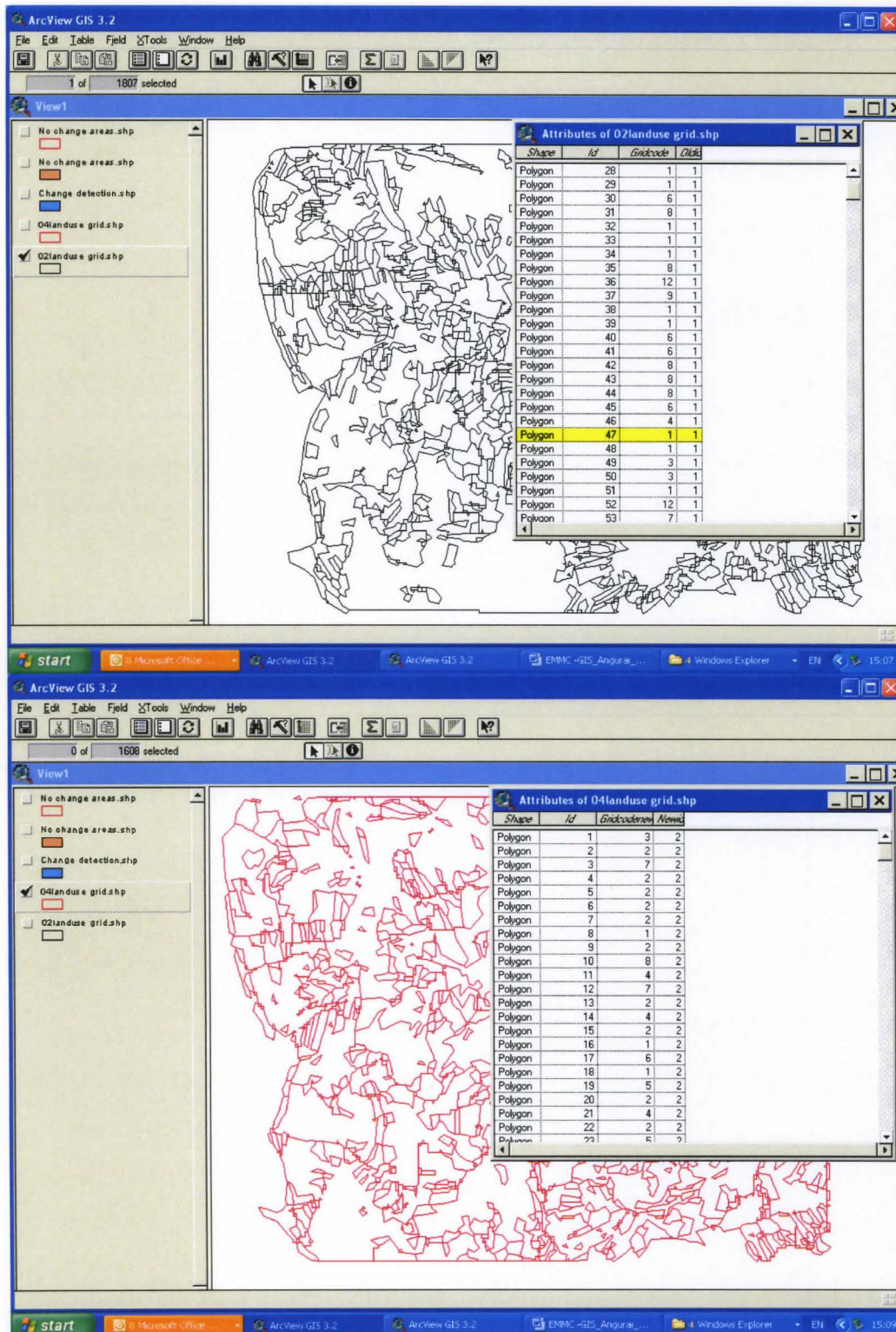


Figure 3 Grid file depicting the 2002 and 2004 land use map respectively.

The conversion of shapefiles to grid format enabled raster processing and editing. In the process many of the smaller polygons were resampled using the nearest method in which the value of the input cell whose centroid is closed to the output cell centroid is assigned the output cell.

The overlays of the two files with differentiated color codes give a visual representation of the land use changes. The changes are not easily interpretable by visual observation.

Grid file with attributes table: Land use type has been assigned a value for example scrubland is assigned value 1, Sorghum 2 etc. Figure 4

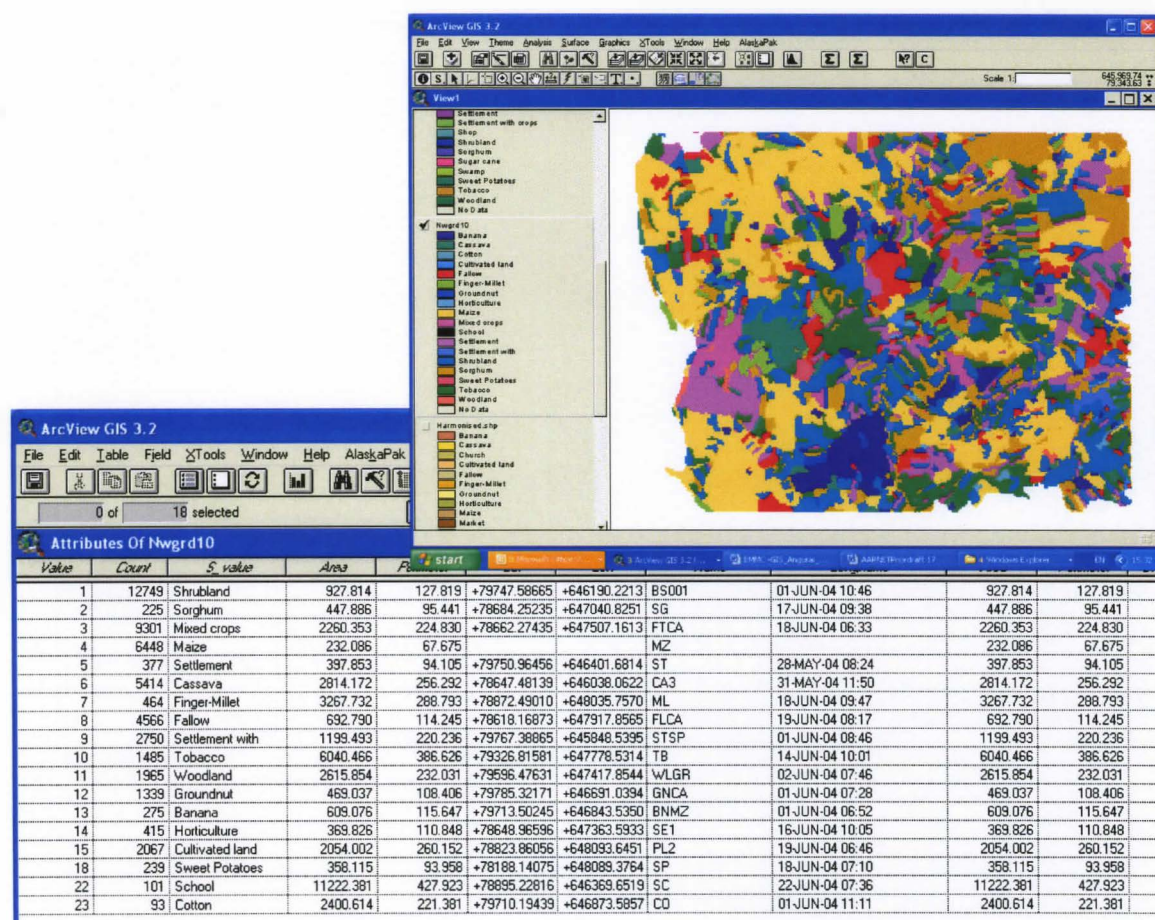


Figure 4. Grid file assignment

The change detection extension designed to extrapolate the changes between grid cell values assigned is then used to quantitatively differentiate the land use between the two grid files specifically analyzing the pixel value assignment for each cell.

The extension indicates the previous land use classification and the current land use type from which change statistics are generated figure 5.

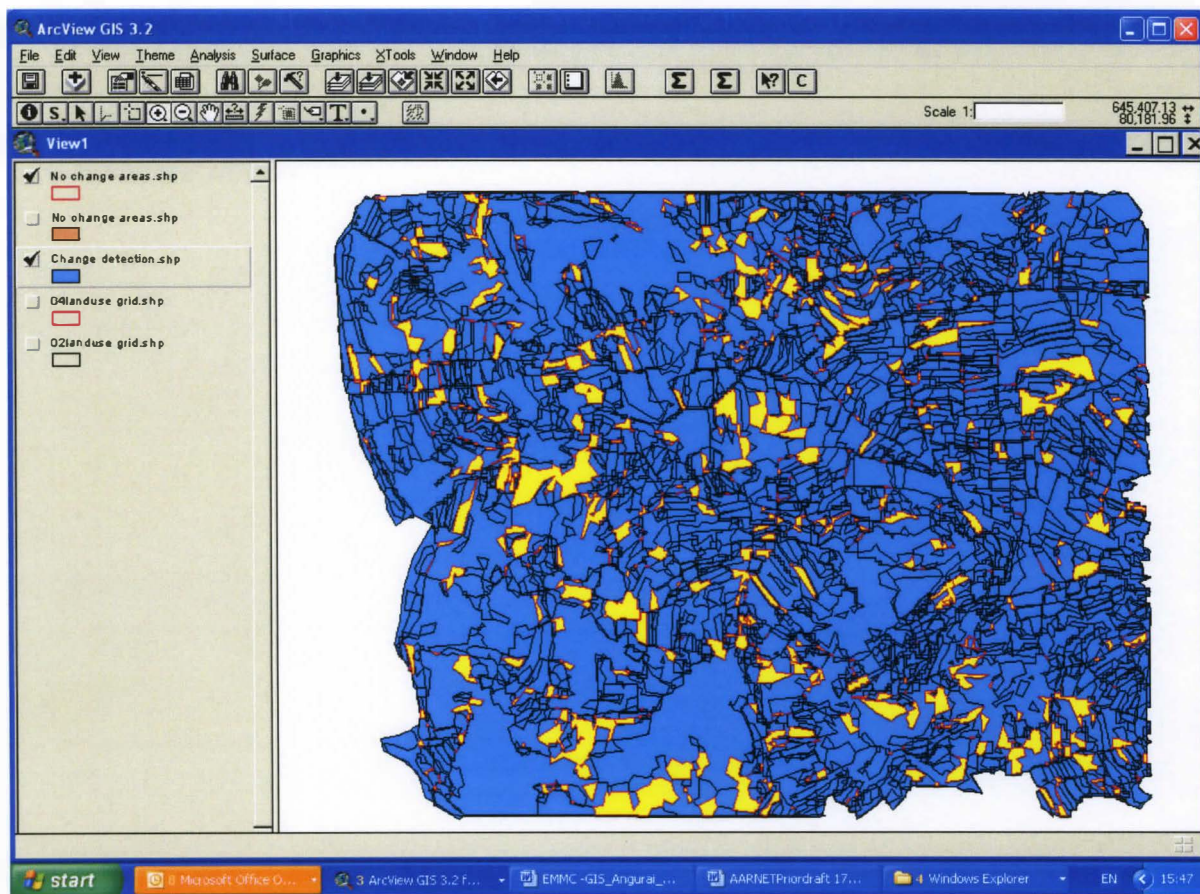


figure 5 change detection extension.

Figure 6 Land use change attributes table

Shape	ID	Parts	Gridcode	Old	GridcodeNew	Area	Perimeter	Hectares	Change
Polygon	1	1	8	1	5	113.719	52.538	0.011	Area was 8 and is 5 now
Polygon	2	1	8	1	0	102.227	51.432	0.010	Area has increased since then
Polygon	3	1	5	1	2	49.501	28.257	0.005	Area was 5 and is 2 now
Polygon	4	1	5	1	2	1.857	7.117	0.000	Area was 5 and is 2 now
Polygon	5	2	5	1	4	87.127	46.663	0.009	Area was 5 and is 4 now
Polygon	6	1	5	1	0	77.461	49.019	0.008	Area has increased since then
Polygon	7	1	1	1	2	68.242	34.109	0.007	Area was 1 and is 1 now
Polygon	8	1	1	1	0	38.731	28.237	0.004	Area has increased since then
Polygon	9	1	2	1	3	136.484	54.891	0.014	Area was 2 and is 3 now
Polygon	10	1	2	1	0	77.461	49.019	0.008	Area has increased since then
Polygon	11	1	1	1	2	59.986	31.331	0.006	Area was 1 and is 2 now
Polygon	12	1	1	1	3	9.246	16.102	0.001	Area was 1 and is 3 now
Polygon	13	1	1	1	2	141.262	55.777	0.014	Area was 1 and is 2 now
Polygon	14	1	1	1	4	274.202	95.677	0.027	Area was 1 and is 4 now
Polygon	15	1	1	1	0	271.115	152.929	0.027	Area has increased since then
Polygon	16	1	7	1	2	28.360	24.753	0.003	Area was 7 and is 2 now
Polygon	17	1	7	1	6	54.181	32.829	0.005	Area was 7 and is 6 now
Polygon	18	1	7	1	0	67.504	45.393	0.007	Area has increased since then
Polygon	19	1	1	1	2	1.262	5.489	0.000	Area was 1 and is 2 now
Polygon	20	1	1	1	9	67.980	33.189	0.007	Area was 1 and is 9 now
Polygon	21	1	1	1	0	38.731	28.237	0.004	Area has increased since then
Polygon	22	1	4	1	3	216.423	79.256	0.022	Area was 4 and is 3 now
Polygon	23	1	4	1	0	826.611	232.258	0.083	Area has increased since then
Polygon	24	1	5	1	2	478.881	90.612	0.048	Area was 5 and is 2 now
Polygon	25	1	5	1	4	368.464	102.987	0.037	Area was 5 and is 4 now
Polygon	26	1	5	1	0	232.384	132.147	0.023	Area has increased since then
Polygon	27	1	3	1	2	591.920	110.733	0.055	Area was 3 and is 2 now
Polygon	28	1	3	1	1	25.237	24.209	0.003	Area was 3 and is 1 now
Polygon	29	1	3	1	6	5.173	12.723	0.001	Area was 3 and is 6 now
Polygon	30	1	3	1	0	154.923	90.583	0.015	Area has increased since then
Polygon	31	1	4	1	2	298.129	93.218	0.030	Area was 4 and is 2 now
Polygon	32	2	4	1	1	83.416	51.807	0.008	Area was 4 and is 1 now

Attributes table depicting the actual changes in the change field, while area and perimeter is reflected per land use row mapped, Figure 6

4.2. Results

Survey results were broadly classified under two main heading

1. The Absolute Percent Change:

The absolute percent change is the percentage of the entire survey area that changed from one **land use type to another** between 2002 and 2004. This gives a sense of the absolute amount of land moving from one land use type to another over time and also provides a measure of the proportion the current land use dispensation in the area.

2. Relative Percent Change:

The relative percent change is the percentage of individual land-use types that changed from one land-use type to another between 2002 and 2004. This measure gives a sense of the comparative rate of change in different land-use types over

time so that relative rates of gain or loss of land-use types with very different areas can be compared to each other

The Absolute Percent Change

The survey classified land use changes into 5 sub- categories these were:

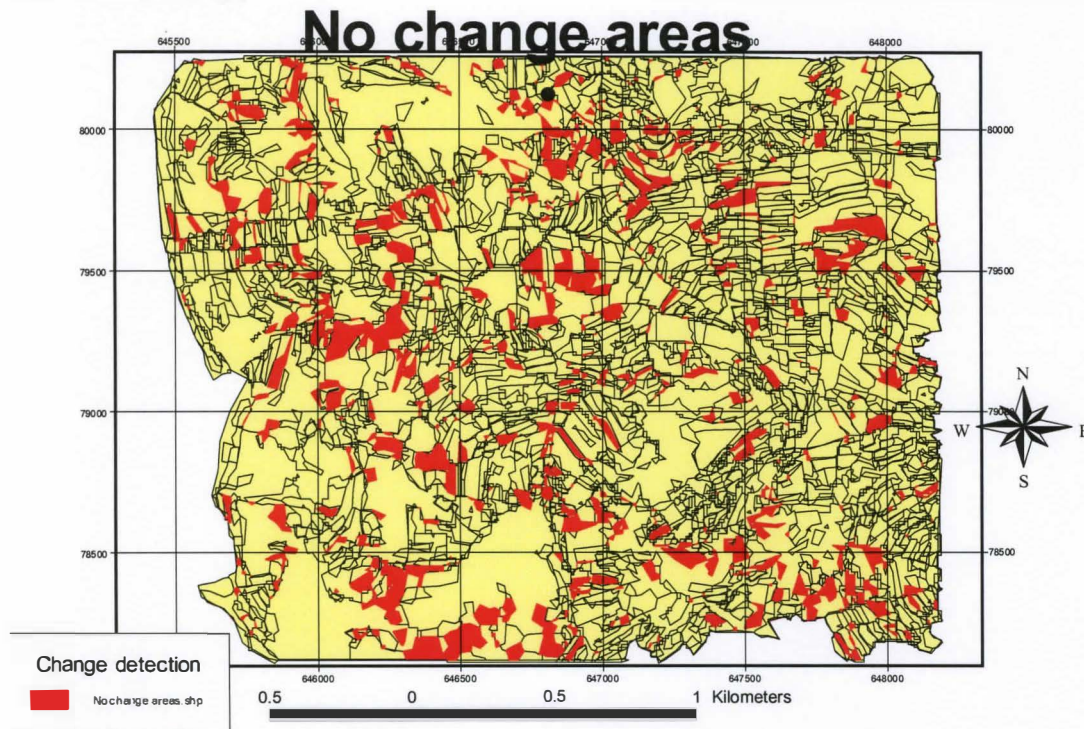
- (i) No change areas
- (ii) Scrubland to crop areas
- (iii) Fallow to crops areas
- (iv) Crops to Fallow area
- (v) Fallow to shrub land
- (vi) Crops to shrub areas
- (vii) Maize to mixed crops
- (viii) Mixed crops to Maize
- (ix) Other crops to Cotton
- (x) Other crops to Tobacco
- (xi) Other crops to Sorghum

The above categories were selected based on the field observation of dominant crops in the survey area and random interviews with key informants. These eleven change models accounted for 84% of the total land use change detection, with remaining 16% classified as other land use changes not modeled.

4.2.1 No change areas. This category witnessed a continuation of the previous land use. This category selected all land use types that remained the same, e.g. if the previous land use was 1 and the current one reported as 1 then this implies the areas is still under shrub land thus no change is noted in its land use. Fig 7 depicts areas that represented no change in their land use.

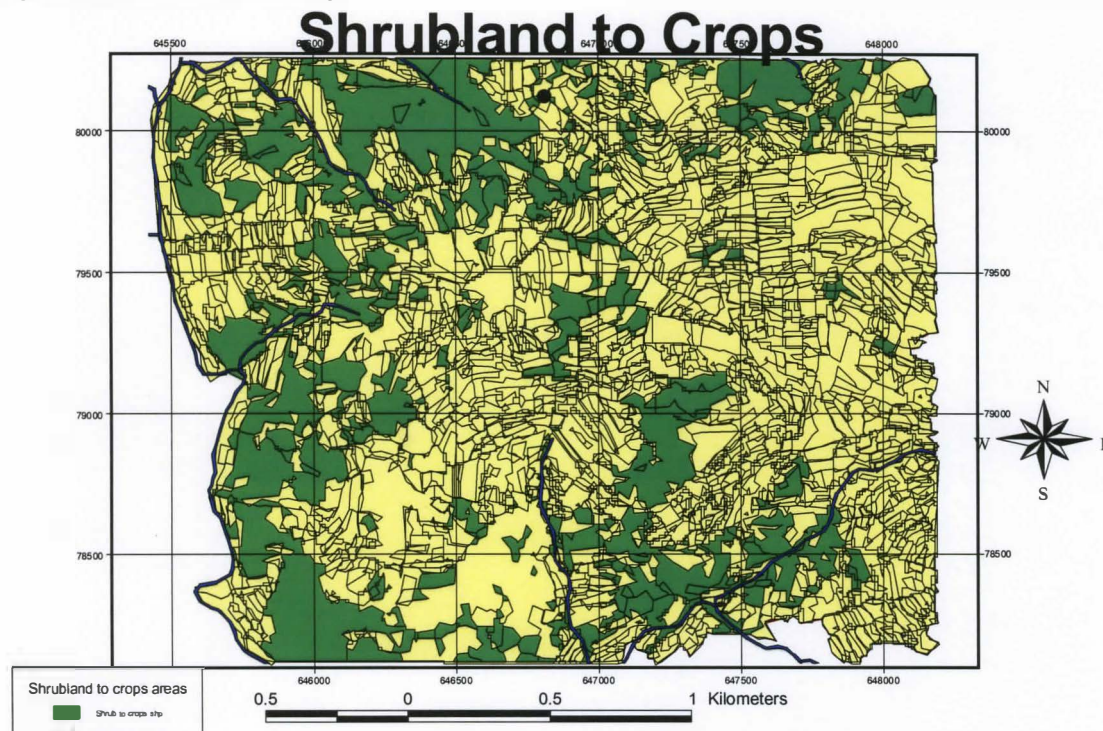
No change category accounted for 9 % of the total land area with a spatial dimension of 497796 sq meters.

Figure 7: No change areas



4.2.2. Shrub land to crop areas witnessed the largest change over the two year period. The area previously under shrub land reduced by 27% representing a cumulative area of 1,481,995 sq meters. This was evident from the clearing of existing shrub land giving credence to the fast disappearance of this land cover. The aspects of steep gradient are not effectively observed leading to speculation that the 27% decimation of previous shrub land reflects the intensive human related activities mainly related to arable farming and livestock grazing. This is one indicator that reflects the impact of tsetse fly control in the area. Many farmers interviewed concurred that the tsetse fly population has drastically reduced since the introduction of traps and moving targets, Fig 8 depicts areas that were previously under shrub land but currently under crops.

Figure 8 Shrub land to Crops



4.2.3 The fallow to crops category recorded a moderate change of 12 % increase with an area of 658388 sq meters, the greatest beneficiary of this change was maize crop which dominated the replacement as reflected in Figure 9.

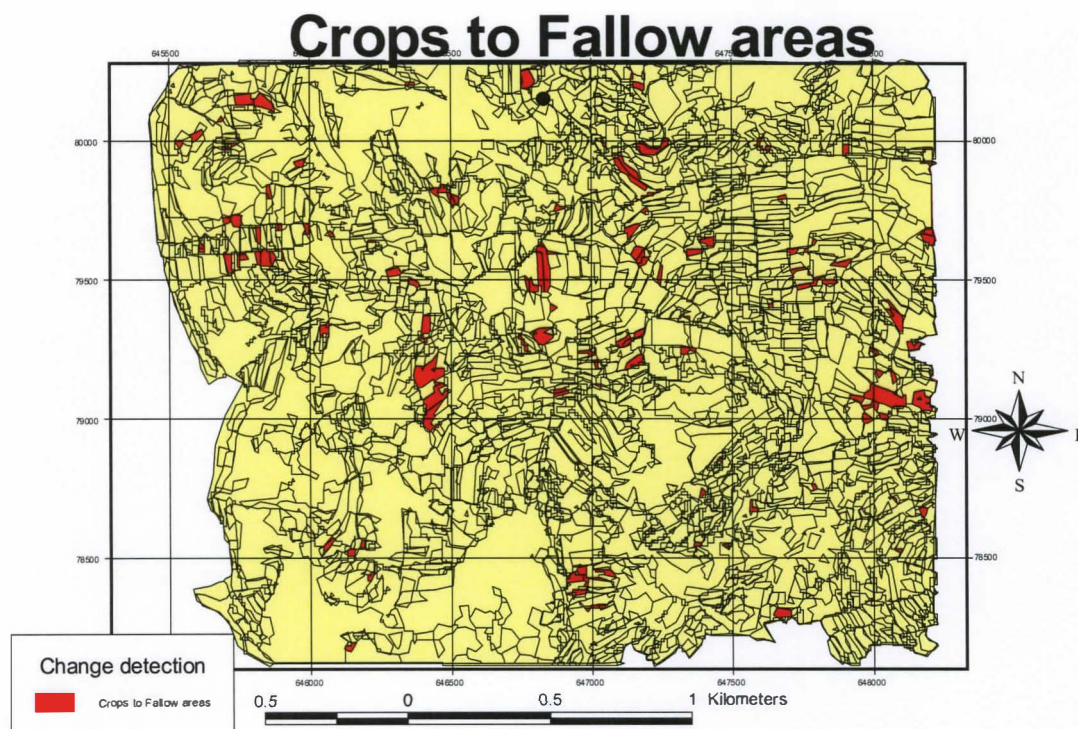
4.2.4 The Crops to shrub land category witnessed a marginal change of 6% of the total land use whose cumulative area 343235 sq meters. This is attributed to the fallow cassava which turns to shrub land. This was rather difficult to classify with most enumerators giving widely varying classification results that were difficult to harmonise given the wide spatial distribution of the mapping area, Figure 10 depicts the change from crops to shrubland.

4.2.5 The Crops to fallow category change was insignificant, the total area change was 128600 sq meters accounting for approximately 4.75% of the land use change. While selecting grid values for the above, the following land use types were omitted as they did not represent crops types.(1-shrubland, 5-settlement, 9-settlement with crops, 13-bananas, 15-cultivated land, 16-church, 3-shop, 19-market) The analysis did not identify any area from the 2002 survey that experienced a change from sugar cane to crops.

Similarly the Fallow to shrub land category was not very significant accounting for 4% of the changed land use .See figure 11.

The low change from crops to fallow probably indicates a shift from the traditional farming methods in which a good percentage of the land was left fallow.

Figure 11: Crops to Fallow areas



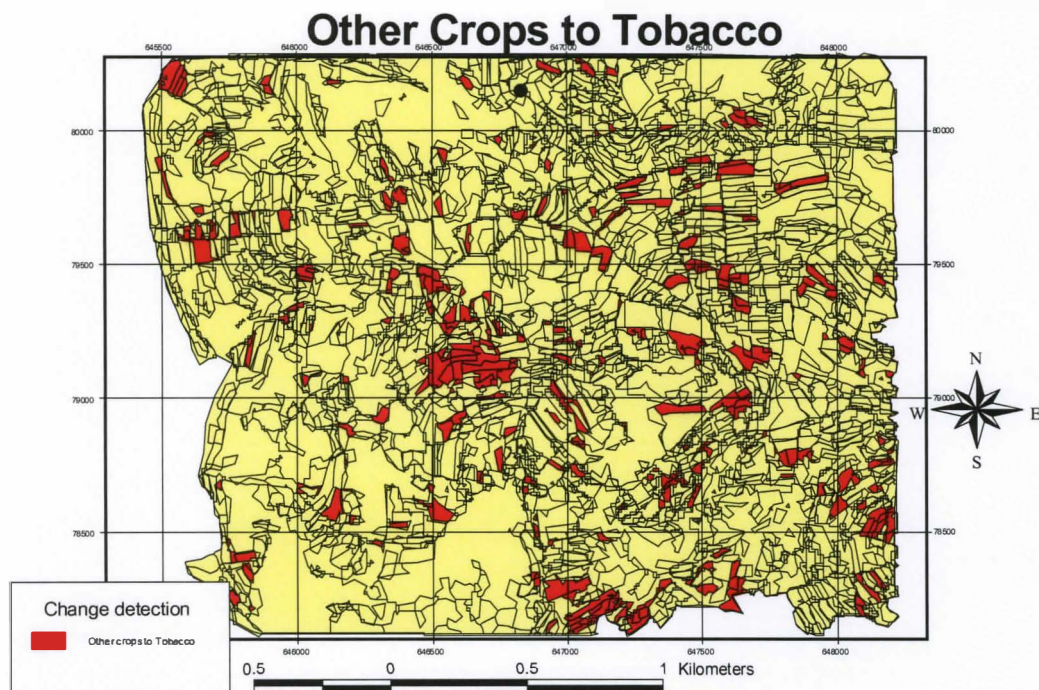
4.2.6 Maize to mixed crops did not experience much change, 0.1 % of the land use change detected, conversely there was insignificant shift from mixed crops to maize accounting for 1. % of the total land use change.

4.2.7 Cash crops

The major cash crops in Katotoi are Tobacco and Cotton. However due to seasonality of the cropping calendar, the 2002 survey did not capture cotton.

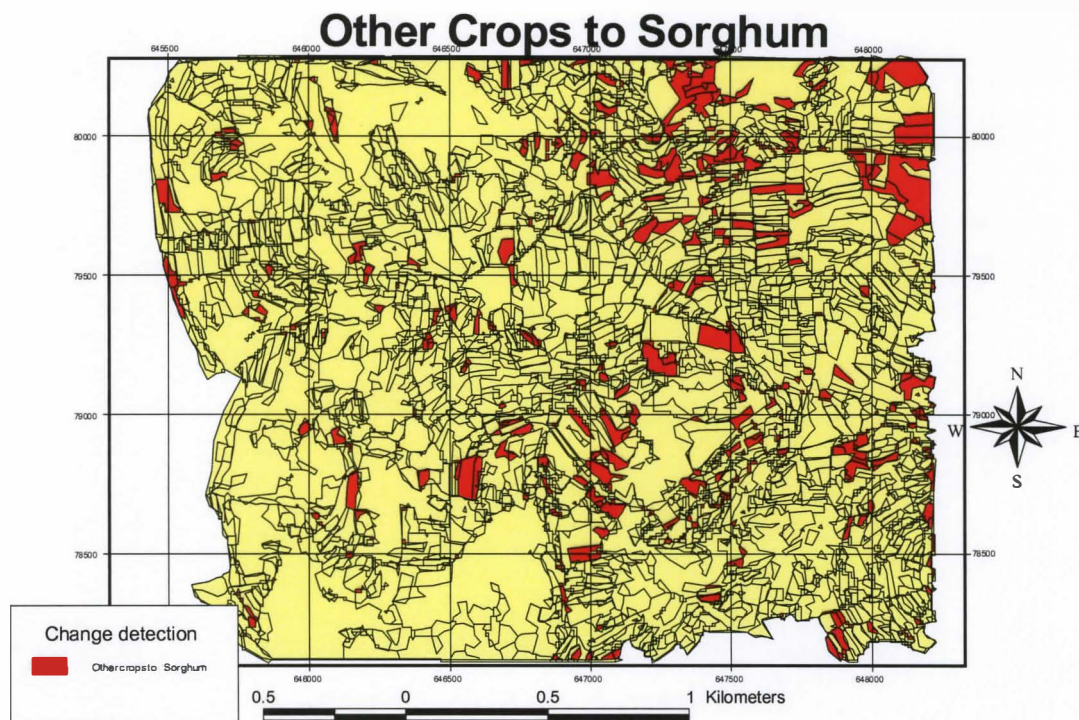
It is noted that under the change detection analysis, a total of 7% of the land that was previously under other crops is now Tobacco accounting for 3956687 sq meters in area figure 12 reflects the changes noted during analysis.

Figure 12 Other Crops to Tobacco



4.2.8 Other Crops to Sorghum experienced a significant change of 7% with a total area of 428226 sq meters. The areas currently under sorghum were previously under tobacco, woodland, ground nut, swamp, mixed crops, maize, cassava, finger millet and some fallow land Figure 12 depicts area that changed to Sorghum

Figure 13: Other crops to Sorghum.



Relative Percent change

Table 2

Crop Type	Percentage of Area of Total cropped Land		
	2002 %	2004 %	Net change
Cassava	23	20	3% decrease
Maize	18	31	13% increase
Tobacco	8	5	3% decrease
Finger Mil/Sorgh mixture*	8	33	25% increase
Finger Millet	4	1.5	2.5% decrease
Ground Nuts	3	3	No change
Banana	2	1	1% decrease
Other Crop	34	6.5	27.5 % decrease
Total	100	100	19% increase

Relative Percent Change

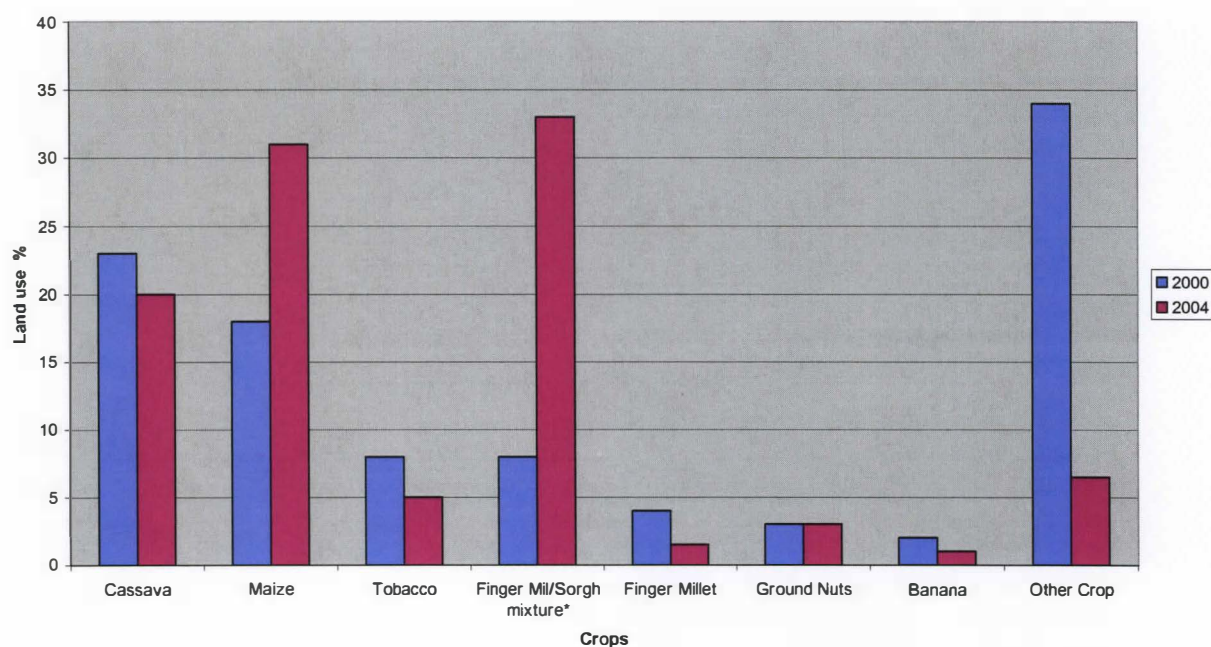


Figure 14: Relative percent change graph.

5.0 Discussion of results

The cumulative 19% increase in total land use area recorded in the 2004 survey relative to 2002 is indicative of the increased ground activity. The field reconnaissance prior to the survey confirmed previous known bush land had been converted to settlement. Maize is the fastest growing crop accounting for 13% of the total increase. Finger Mil/Sorghum mixture which recorded 8% and 33% in 2002 and 2004 respectively accounting for 25% increase cannot be authoritatively included in the survey as the categorization may account for the this large increase. Other Crops recorded a 34% and 6.5% during the 2002 and 2004 survey reflecting a 27.5 % decrease; however, the crops listed in this category are not verifiable.

The surprise occurrence was the complete decimation of the swamp area. This has been totally converted to crop land with sugar cane being one of the crops planted. This will have adverse effects on the biodiversity of locally. Farmers interviewed indicated a pressing need for more land, a scarce resource necessary for their survival thus the decimation of the swamp area.

The GIS software used in the analysis (Arc-info) contributed towards the automatic elimination of very small polygons mapped as land use types. The fuzzy tolerance of 0.05 and error margin of 0.005 RMS had the effect of amalgamating smaller polygons with their larger neighbors. This was necessary as most of the smaller polygons could not be plotted on the standardized map scale for the entire survey area.

The survey offered an insight to the actual activities currently undertaken in the Katotoi area of Angurai. It is recommended that a similar study be carried out after every three years to ascertain the impact of Tsetse eradication in the area. It should however be noted that the increased land use may have negative biodiversity and soil erosion effects as the cultivation is now targeting forest areas and steep hill slopes. These are vital water catchments and carbon sink areas that are threatened with extinction with dire environmental consequences for the local populace.

References

1. Daniel Bourzat, Joseph Maitima, Meshack Nyabenge and Robin Reid, April 2002: First Year Annual Report, Farming in Tsetse Controlled Areas Regional Component.
2. Government of Kenya, Office of the Vice President and Ministry of Planning and Development: Teso District Development Plan, 1997-2001. Government Printer, Nairobi.